CentER

Discussion paper

No. 2002-02

THE DYNAMICS OF THE IMPACT OF PAST PERFORMANCE ON MUTUAL FUND FLOWS

By Alexei P. Goriaev, Theo E. Nijman and Bas J.M. Werker

January 2002

ISSN 0924-7815

The dynamics of the impact of past performance on mutual fund flows

Alexei P. Goriaev, Theo E. Nijman, and Bas J.M. Werker*
Department of Finance and Finance Research Group
CentER, Tilburg University

December 17, 2001

*Corresponding author: Alexei Goriaev, Finance Research Group CentER, Tilburg University, P.O. Box 90153, 5000 LE Tilburg, The Netherlands. E-mail: A.Goriaev@kub.nl. We have benefited from comments of participants of the CEPR/JFI symposium "Institutional Investors and Financial Markets: New Frontiers" at INSEAD (April 2001) and SIRIF conference "Performance of managed funds: Do fund managers add value?" in Edinburgh (June 2001).

The dynamics of the impact of past performance on mutual fund flows

Abstract

This study reconsiders the determinants of flows into US growth funds, focusing in particular on the dynamics of the impact of past performance on flows. We model the flow-performance relationship at the monthly frequency, allowing for dependence of the sensitivity of flows to past performance on size and age of the fund. The dynamics of the impact of past performance is modelled using polynomial lag structures. Performance from 6 to 8 months ago seems to have the strongest impact on net flows to US growth funds. We observe that performance during the most recent quarter is less important than performance during the remaining three quarters of the first year, suggesting that some investors react to fund performance with a certain lag. Specifications based on average past performance at annual or quarterly frequency are strongly rejected. The first three years of past performance history account for about 90 percent of the total impact of past performance on flows. The well-documented convexity of the flow-performance relationship appears robust to allowing for dependence of this relationship on size and age of the fund. The return on systematic risk factors has a small additional impact on top of the impact of risk-adjusted returns.

Keywords: flow-performance relationship, investor behavior.
JEL Classification: G11.

1 Introduction

Many studies have recently analyzed the determinants of the behavior of mutual fund investors, concentrating on the relation between net inflows to mutual funds and their past performance. This research is of obvious relevance both for managers of mutual funds and their regulators. For the managers, it is important to know the factors that determine the total net assets under management which drive their compensation. The regulators should be aware of the incentives for risk-taking induced to managers by the existing investor behavior patterns.

The stylized findings indicate a clear positive impact of both risk-adjusted as well as raw past performance on subsequent net inflows (see, e.g., Ippolito [1992] and Gruber [1996]). The relationship appears convex, indicating that most of the inflows are attracted by the best performing funds (see, e.g., Chevalier and Ellison [1997] and Sirri and Tufano [1998]). Flows are also directly related to fund visibility, as funds belonging to larger families (see Sirri and Tufano [1998]) and funds advertising in the financial magazines (see Jain and Wu [1999]) tend to attract larger flows. Moreover, flows into a fund are found to be positively related to the performance of the fund family, measured, e.g., as average performance within the family (see, e.g., Ivkovic [2000]) or through the presence of star performers in the family (see, e.g., Nanda, Wang, and Zheng [2000]). Barber, Odean, and Zheng [2001] find that fund flows are more sensitive to the salient fees such as loads and commissions than to operating expenses. Del Guercio and Tkac [2000] document that mutual fund investors use less sophisticated measures of fund performance than pension fund clients.

The findings on the flow-performance relationship can be compared to the predictions based on the literature on performance persistence of mutual funds (see, e.g., Hendricks, Patel, and Zeckhauser [1993], Chevalier and Ellison [1999], Wermers [2000], Baks, Metrick, and Wachter [2001], and many others). In general, these studies find strong evidence of persistence among bad performers and mixed evidence for consistent superior persistence. This implies that the relationship between fund flows and past performance should be the strongest among the worst-performing funds, which is opposite to the observed pattern (see Sirri and Tufano [1998]). This difference can be explained by a number of institutional and psychological factors, which prevent large outflows from funds with bad past performance. Market frictions such as the presence of search costs, back-end load charges, tax considerations, and restrictions of the investment retirement plans increase the transaction costs of withdrawing money from the poorly performing funds, while status-quo bias (see Zeckhauser, Patel, and Hendricks [1991]) and cognitive dissonance bias (see Goetzmann and Peles [1997]) make investors ignore information about bad fund performance.

Most studies referred to above focus on the impact of average past performance on fund flows at an annual frequency. In contrast, we analyze the full dynamic structure of the flow-performance relationship at the monthly frequency. As noted by Geweke [1978], low (e.g., annual) frequency analysis of the flow-performance relationship can be biased in a non-trivial way, if the true link is at higher frequency, and clearly cannot reveal the full high frequency lag structure. We find that performance from 6 to 8 months ago has the strongest impact on net flows to US growth funds. The performance during the most recent quarter appears less important than performance during the rest of the past year. This suggests that information dissemination takes time and some investors react to fund performance with a certain lag. The first three years of performance history account for about 90% of the total impact of past performance on flows. Moreover, almost all studies referred to above assume that the flow-performance sensitivity is constant. We find evidence that relative flows of small and, to a lesser extent, young funds are much more sensitive to past performance than larger and older funds.

As stated above, many studies (e.g., Chevalier and Ellison [1997] and Sirri and Tufano [1998]) have found a convex flow-performance relationship, indicating that funds with top recent performance attract most of the inflows. This stylized finding, together with the fact that the manager's compensation is typically a percentage of the fund's net assets (see Khorana [1996]), has lead to the hypothesis that managers of funds with poor performance in the first half of the year have an incentive to increase risk in the second half of the year. Tests of this hypothesis have been reported, e.g., by Brown, Harlow and Starks [1996], Busse [2001], and Goriaev, Nijman, and Werker [2001]. We find in the present paper that the convexity of the flow-performance relationship is robust to allowing for more flexible dynamic lag structures and dependence of the flow-performance sensitivity on age and size of the fund. This convexity appears to be mostly due to the difference in flows between the top performing half of the funds and bottom performing half of the funds. However, within each of these two segments the flow-performance relationship is close to linear, which suggests that primarily funds with the average performance have incentives to take excessive risk.

Finally, we find that the return on systematic risk factors in the last two years or so has a small positive impact on flows in excess of the impact of the risk-adjusted returns. This might indicate that mutual investors are style timers.

The structure of the remainder of the paper is as follows. Section 2 describes the data set and methodology and discusses the relation between the typical model used in the literature and our basic model specification. In Section 3, we compare the empirical results based on the two models. We also discuss our findings concerning the lag structure of the flow-performance relationship. In Section 4, we estimate the lag structure over a longer period (from 1976 to 1998), using quarterly data on funds' total net assets in 1976-1990. Sections 5 and 6 present the results concerning the convexity of the flow-performance relationship and additional impact of raw returns on flows (in excess of the risk-adjusted returns), respectively. Section 7 concludes.

2 Data and methodology

The data employed in our analysis are provided by Micropal. The data set includes the month of fund foundation, total net assets, and total returns of the US funds for the period January 1970 to December 1998. While returns are available at the monthly frequency throughout this period, total net asset values are available at monthly frequency from December 1990 and at quarterly frequency in 1970-1990. The main sample period in our study is consequently taken as January 1991 to December 1998. In Section 4, we also incorporate the quarterly data on funds' total net assets in a period before 1991. In order to avoid heterogeneity based on differences in fund styles, we perform the analysis on US growth funds only. Since we use a five-year horizon for fund performance, our analysis is restricted in each month to the funds with at least five years of the return history. Note that we have annualized monthly returns and flows in order to make our results comparable to existing evidence, which is based on the annual data.

In order to reduce the impact of typos and mergers, we exclude from our data set 1% of outliers based on net relative flows (0.5% of funds with the largest positive relative flows and 0.5% of funds with the largest negative relative flows). In order to concentrate on the flow-performance relationship for moderately sized funds and avoid that the results are determined by outliers, we also excluded 1% of the observations with the largest size, which belong to only 6 funds and span from 11 to over 80 billion dollars. Table 1 presents descriptive statistics of the fund characteristics. During the main sample period (1991-1998), an average fund had \$732 million of assets and experienced an inflow of \$50 million or 5.4% per year, ranging from \$215 million outflow for the bottom quintile to \$460 million inflow for the top quintile.

Note that our data set contains only funds that were still in operation in the beginning of 1999 and is survivorship biased. However, it is straightforward to show that it does not affect the consistency of OLS or WLS estimates, if past flows do not influence the probability of fund survival in a joint regression with returns. This assumption is fully in line with the empirical findings in Brown and Goetzmann [1995]. Not surprisingly, Chevalier and Ellison [1997], Goetzmann and Peles [1997], and Sirri and Tufano [1998] find the same results for survivorship biased and unbiased samples.

Traditionally (see, e.g., Gruber [1996]), net absolute flows are defined as the change in fund assets net of reinvested dividends:

$$F_{i,t} = TNA_{i,t} - TNA_{i,t-1}(1 + R_{i,t}), \tag{1}$$

where $TNA_{i,t}$ denotes fund i's total net assets at the end of month t and $R_{i,t}$ is return of fund i in month t. Similarly, net relative flows are defined as a net percentage growth of fund assets:

$$f_{i,t} = \frac{TNA_{i,t} - (1 + R_{i,t})TNA_{i,t-1}}{TNA_{i,t-1}} = \frac{F_{i,t}}{TNA_{i,t-1}}. \tag{2}$$

Both definitions are based on an assumption that all investor earnings are automatically reinvested in the fund and flows occur at the end of month t. To account for the impact of the inflation, we deflate funds' total net asset values by the US consumer price index and convert them into equivalent US dollars, as of December 1990 before computing flow measures.

Almost all studies referred to in the previous section analyze flows at the annual frequency, assuming that the sensitivity of flows with respect to past performance is the same for all funds. Thus, the standard model in the literature specifies net relative flows as a linear function of past performance and a set of control variables:

$$f_{i,t} = a + b_1 r_{i,t-1} + ... + b_K r_{i,t-K} + c' x_{i,t-1} + u_{i,t}, \tag{3}$$

where $r_{i,t-i}$ is some measure of fund i's performance (e.g., raw return, Jensen's alpha, or corresponding ranking) in period $t-i$ and $x_{i,t-1}$ includes such variables as fund size, age, fees, a measure of riskiness, and performance of other funds in the family. The assumption that the flow-performance sensitivity coefficients b_1 to b_K do not depend on fund characteristics, such as size and age, is clearly restrictive. Moreover, one should keep in mind that small funds have extreme relative flows that dominate OLS estimates. Unless heteroskedasticity-consistent standard errors are computed, inference based on OLS estimates will be biased. For efficiency reasons, we model the variance of the error term and compute weighted least squares estimates.

In this paper, we try to model the impact of past performance on flows in a less restrictive way. We write our model first in terms of absolute flows, where we specify both the performance-unrelated part and the flow-performance sensitivity of the flow model as polynomials in logs of fund size and age:

$$F_{i,t} = G(TNA_{i,t-1}, age_{i,t-1}) + H(TNA_{i,t-1}, age_{i,t-1}) \sum_{j=1}^{60} w_j RAR_{i,t-j} + e_{i,t}, \tag{4}$$

where functions G and H approximate the unknown functional form of the performance-unrelated and performance-related parts of the relationship between flows and performance.

The empirical results to be presented later suggest that a specification with second-order polynomials in logs of fund size and age suffices.[1]

Equivalently, we can rewrite the model in terms of relative flows. After dividing both sides of (4) by $TNA_{i,t-1}$, we obtain

$$f_{i,t} = g(TNA_{i,t-1}, age_{i,t-1}) + h(TNA_{i,t-1}, age_{i,t-1}) \sum_{j=1}^{60} w_j RAR_{i,t-j} + \tilde{e}_{i,t}, \qquad (5)$$

where $g(\cdot) \equiv G(\cdot)/TNA_{i,t-1}$, $h(\cdot) \equiv H(\cdot)/TNA_{i,t-1}$, and $\tilde{e}_{i,t} \equiv e_{i,t}/TNA_{i,t-1}$.

Fund performance over the past five years is measured as a weighted sum of past risk-adjusted returns defined on the basis of the four-factor model with the market, size, book-to-market, and one year momentum factors[2], as in Carhart [1997]:

$$RAR_{i,t-j} \equiv R_{i,t-j} - R^f_{t-j} - \sum_{l=1}^{4} \hat{\beta}^l_i F^l_{t-j}, \qquad (6)$$

where $F_t = (R^m_{t-j} - R^f_{t-j}, SMB_{t-j}, HML_{t-j}, MOM_{t-j})$ and $\hat{\beta}^1_i, ..., \hat{\beta}^4_i$ are estimated using all observations available for a given fund. In order to ensure the smoothness of the impulse response function, we impose a polynomial structure on the performance coefficients. We approximate the distribution of the lag coefficients on risk-adjusted returns by a polynomial of the p-th order:

$$w_j = \sum_{k=0}^{p} \theta_k k! j^{-k} \text{ for } j = 1, ..., 60. \qquad (7)$$

The empirical results indicate that $p = 5$ suffices. Since we expect that the impact of past performance disappears after at most five years, we impose the end-point restriction that $w_{61} = 0$. In order to identify the model, we normalize the weights, so that the average of the performance coefficients is equal to one: $\frac{1}{60} \sum_{j=1}^{60} w_j = 1$. The performance coefficients represent the weights with which investors take past performance into account. If all weights are equal to each other (i.e. $\theta_k = 0$ for $k > 0$), the weighted sum of risk-adjusted returns in (4) equals Jensen's alpha over a five-year estimation period.

Throughout the paper, we compute weighted least squares estimates where the variance of $e_{i,t}$ is modelled as

$$Var(e_{i,t}) = \exp U(TNA_{i,t-1}, age_{i,t-1}), \qquad (8)$$

with U being a second-order polynomial in logs of fund size and age. This specification reflects that the disturbances of both the absolute flows specification (4) and the relative

[1] The joint hypothesis that the third-order terms are zero is not rejected at the conventional confidence level.

[2] We thank Kenneth R. French for the opportunity to use the factor returns provided at his website (http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html).

flows specifications (5) are heteroskedastic, in contrast to what is often assumed in the literature. The coefficients of the function U are estimated on the basis of the OLS residuals.

We estimate the model parameters in (4) by means of a concentrated least-squares approach. For the pre-specified values of the parameters in the function H, the model (4) is linear in the remaining parameters. Therefore, the least squares estimates can conveniently be computed by numerically maximizing the concentrated sum of squares over the parameters in the function H.

3 Basic results

A typical example of a specification considered in the literature is

$$f_{i,t} = a + c_1 \log TNA_{i,t-1} + c_2 \log age_{i,t-1} + b\alpha_{i,t} + u_{i,t}, \tag{9}$$

where fund performance is measured as Jensen's alpha $\alpha_{i,t}$ over a five-year period. This is equivalent to imposing $w_1 = ... = w_{60} = \frac{1}{60}$ in our basic specification (5). Moreover, the performance-unrelated part of the model, g in (5), is specified as being linear in logs of fund size and age, while the flow-performance sensitivity, h in (5), is simply taken to be constant.

The estimation results for the model (9) are reported in Table 2. In line with the existing evidence, we find that better performing funds, smaller funds, and younger funds attract larger relative flows. The dependence of the performance-unrelated part of the specification for relative flows (the function g) on fund size and age is illustrated graphically in Panel A of Figure 1.[3] This figure shows that the expected flows of funds with a neutral past performance (i.e., with Jensen's alpha equal to zero) range from -3% for large old funds to 9% for small young funds. The model imposes that the flow-performance sensitivity of relative flows (the function h) is constant over funds (see Panel B in Figure 1). It predicts that 1% change in Jensen's alpha will lead to 3.8% change in expected relative flows, which is consistent with the findings in, e.g., Chevalier and Ellison [1997]. It can readily be seen that the current specification may be too restrictive, since it predicts negative flows for old funds with neutral performance and the same sensitivity for the smallest and the largest funds.

The estimation results for the basic specification as put forward in (4) to (8) are presented in the third and fourth columns of Table 3. All coefficients are highly significant,

[3] In all graphs depicting expected fund flows as a function of size and age, size and age axes start from $250 million and 5 years, respectively. We exclude the segment of the smallest funds because of the large standard errors of their expected relative flows.

which allows us to reject the hypothesis that the sensitivity of flows to performance is the same for all funds. The expected performance-unrelated flows rise from 0.5% for large old funds to 2% for large young funds and 10-16% for small young funds (see Panel A in Figure 2). This pattern looks much more reasonable than the one based on the restrictive specification (9) typically used in the literature. The peak of 16% in the segment of smallest youngest funds can be explained by the observation that smallest funds tend to have negative Jensen's alpha in a range from -2% to -3%, which compensates the peak. The flow-performance sensitivity is also higher for smaller and younger funds (see Panel B in Figure 2). It ranges from 0.5% for large old funds to 5-8% for small young funds. Thus, flows to small and, to some extent, young funds appear much more sensitive to past performance than flows to large and old funds. One possible explanation is that investors invest approximately equal dollar amounts in the best performing funds, irrespective of their current size, which would make the relative flow to small funds much more sensitive to past performance. Moreover, investors may be more sensitive to the recent performance of young funds, since they have not yet obtained the reputation established by the old funds.

The hypothesis that average past risk-adjusted performance over a five-year period determines subsequent inflows, i.e., that $\theta_k = 0$ for $k > 0$, is strongly rejected. The impact of past performance on subsequent flows that is implied by (9) and the estimated θ's is illustrated in Panel A of Figure 3. The information content of past performance rises during the first eight months and then gradually decreases towards zero. As indicated by the confidence bands in Panel A of Figure 3, the specification on the basis of average past risk-adjusted performance at annual or quarterly frequency is strongly rejected. Current flows are most strongly affected by the performance from 6 to 8 months ago. The performance during the most recent quarter appears less important than performance during the rest of the past year. This suggests that information dissemination takes time and some investors react to fund performance with a certain lag. Consistent with previous findings (see, e.g., Sirri and Tufano [1998]), fund performance during the most recent year has the strongest impact on flows, accounting for 43% of the total impact. The sensitivity of flows to past performance fades away after a period of three years.

Formal tests of statistical significance of the results are reported in Panel A of Table 4. In the lower diagonal part of the table we present p-values of Wald tests of the hypothesis that the impact of past performance i months ago equals that of j months ago: $H_0 : w_i = w_j$. The upper diagonal part of the table reports p-values of Wald tests of the hypothesis that the impact of average past performance i quarters ago equals that of j quarters ago: $\mathrm{H}_0 :$ $w_{3i-2} + w_{3i-1} + w_{3i} = w_{3j-2} + w_{3j-1} + w_{3j}$. The table indicates that the impact of average performance three quarters ago differs significantly from the impact of average performance one, two and four quarters ago (p-values of 0.0058, 0.0019, and 0.0001, respectively).

4 Extension of the sample period using quarterly data on Total Net Assets

In this section, we estimate the lag structure of the flow-performance relationship over a longer time span, from 1976 to 1998. Since the data on funds' total net assets before 1991 are only available at quarterly frequency, we calculate quarterly flows from the monthly flows over that quarter. After adding the basic equation (4) for three consecutive months and dividing by 3, we obtain

$$\begin{aligned}&\tfrac{1}{3}(F_{i,t}+F_{i,t-1}+F_{i,t-2})=\tfrac{1}{3}\textstyle\sum_{l=1}^{3}G(TNA_{i,t-l},age_{i,t-l})+\\&\tfrac{1}{3}\textstyle\sum_{l=1}^{3}[H(TNA_{i,t-l},age_{i,t-l})\sum_{j=1}^{60}w_jRAR_{i,t-j-l+1}]+\tfrac{1}{3}\sum_{l=1}^{3}e_{i,t-l+1}.\end{aligned}\tag{10}$$

Since monthly flows in (4) are annualized, the left-hand side of the equation is equal to the annualized quarterly net flow realized during months $t-2$ to t: $F_{i,t:t-2}$. Since monthly net assets values are not observed for the first part of the sample period we approximate the specification by

$$\begin{aligned}&F_{i,t:t-2}=G(TNA_{i,t-3},age_{i,t-3})+\\&H(TNA_{i,t-3},age_{i,t-3})\textstyle\sum_{j=1}^{60}w_j(RAR_{i,t-j}+RAR_{i,t-j-1}+RAR_{i,t-j-2})+\tilde{e}_{i,t}.\end{aligned}\tag{11}$$

We estimate the flow-performance relationship combining the modified model (11) for quarterly flows during the first part of the sample period (1976-1990) and basic model (4) for monthly flows during the second part of the sample period (1991-1998). We impose the same identifying and end-point restrictions and polynomial structure, as before (see (6) and (7)). The last two columns of Table 3 and Panel B in Table 4 report the results, which are very similar to those based only on monthly flows in 1991-1998. The parameters in the G and H functions are estimated more precisely due to the additional information about the quarterly flows in 70s and 80s. The lag structure has the same general shape as before, with the impact of performance on flows rising during the first three quarters ago and fading subsequently to zero (see Panel B in Figure 3). Note that the standard errors of the performance coefficients have somewhat increased, which could be explained by temporal changes in the lag structure.

5 Convexity of the flow-performance relationship

In the previous sections, we assumed that the flow-performance relationship is the same for good and bad performers. In this section, we re-examine the existing evidence on non-linearity of the flow-performance relationship by allowing the impact of past performance to be different in each of five segments corresponding to performance quintiles based on five-year Jensen's alpha. The kink points between the segments are the quintile points of the estimated distribution of Jensen's alphas. Formally, we rewrite the basic model (4) as

$$F_{i,t} = G(TNA_{i,t-1}, age_{i,t-1}) + H(TNA_{i,t-1}, age_{i,t-1}) \sum_{p=1}^{5} \sum_{j=1}^{60} w_j(p) RAR_{i,t-j} + e_{i,t}, \quad (12)$$

where we allow each performance coefficient w_j to be different across quintiles. We impose the identifying restriction $\frac{1}{300} \sum_{p=1}^{5} \sum_{j=1}^{60} w_j(p) = 1$ and specify a polynomial structure of the fifth order for the performance coefficients in each segment:

$$w_j(p) = \sum_{k=0}^{5} k! \theta_k(p) j^{-k} \text{ for } j = 1, ..., 60. \quad (13)$$

The end-point restriction is imposed in every segment. Table 5 (columns three and four) presents the results. The impulse response function is very similar in all quintiles, as the flow-performance sensitivity peaks in a period 6-8 months ago and then converges towards zero (see Panel A in Figure 4). However, flows to the better-performing funds appear much more sensitive to past performance than flows to badly performing funds. The hypothesis of linearity of the flow-performance relationship, formulated in terms of the average quintile-specific performance coefficients as $H_0 : \sum_j w_j(p) = \sum_j w_j(r)$, $\forall p, r$, is clearly rejected. The corresponding Wald test has a p-value below 0.0001. Thus, we find that the well-documented convexity of flows with respect to past performance found in other studies (see, e.g., Chevalier and Ellison [1997] and Sirri and Tufano [1998]) is robust to allowing for dependence of this relationship on size and age of the fund. Apparently, this convexity is mostly due to the difference in flow-performance sensitivity between the top three and bottom two performance quintiles. As reported in the lower diagonal part of Table 6, all but one pair-wise differences in the average performance coefficients between the quintiles from these segments are significant at 1% level. The convexity pattern is illustrated in Panel B of Figure 4, which depicts relative flows as a function of the outperformance with respect to the market for an average fund and funds with different combinations of size and age. According to our model, an average fund is expected to lose about 12% in outflows when underperforming the market by 5% per year and is expected to gain about 18% in inflows when outperforming the market by 3% per year. Given the same performance, a small old fund would lose about 14% in outflows, while small young fund would attract about 40% inflows. As we saw before, flows to large funds are much less sensitive to past performance.

6 The impact of benchmark risk

So far, we have demonstrated a strong positive relation between fund flows and risk-adjusted returns. Similar results can be obtained for raw returns, since raw and risk-adjusted returns of US growth funds are highly correlated. An interesting question is whether raw returns add something to risk-adjusted returns in explaining fund flows. To answer that question, we add raw returns as one more performance measure to our basic model (4):

$$F_{i,t} = G(TNA_{i,t-1}, age_{i,t-1}) + H(TNA_{i,t-1}, age_{i,t-1})[\sum_{j=1}^{60} w_j RAR_{i,t-j} + \sum_{j=1}^{60} v_j R_{i,t-j}] + e_{i,t}, \tag{14}$$

where as before we impose a polynomial structure, the end-point restrictions, and an identifying restriction that $\frac{1}{60}\sum_{j=1}^{60}(w_j+v_j) = 1$. Note that since raw returns can be disentangled into the risk-adjusted and systematic risk components (factors are defined as in (6)):

$$R_{i,t-j} = RAR_{i,t-j} + R^f_{t-j} + \sum_{l=1}^{4} \hat{\beta}^l_i F^l_{t-j}, \tag{15}$$

we can rewrite the model (14) as

$$F_{i,t} = \tilde{G}(TNA_{i,t-1}, age_{i,t-1}) + H(TNA_{i,t-1}, age_{i,t-1})[\sum_{j=1}^{60} \tilde{w}_j RAR_{i,t-j} + \sum_{j=1}^{60} \tilde{v}_j (\sum_{l=1}^{4} \hat{\beta}^l_i F^l_{t-j})] + e_{i,t}, \tag{16}$$

where $\tilde{w}_j = w_j + v_j$, $\tilde{v}_j = v_j$, and $\tilde{G}(\cdot) = G(\cdot) + H(\cdot)\sum_{j=1}^{60} v_j R^f_{t-j}$.

The estimation results are presented in Table 7 and Figure 5. We find that both types of performance are positively related to flows. The results indicate that the $\tilde{v}_j$ coefficients are small, but statistically significant. The recent outperformance on the systematic risk factors does yield additional inflow, which indicates that some mutual fund investors are style timers. The inclusion of the $\tilde{v}_j$ coefficients hardly affects the estimates of the $\tilde{w}_j$ coefficients.

7 Conclusion

In this paper, we analyze the dynamic structure of the impact of past performance on fund flows. The flow-performance relationship is estimated at the monthly frequency, allowing for dependence of the sensitivity of flows to past performance on size and age of the fund. Traditional model specifications in the literature based on average past performance at annual or quarterly frequency are strongly rejected. We find that the impact of past performance on flows does not monotonically decay with time. Performance from 6 to 8 months ago seems to have the strongest impact on net flows to US growth funds. We observe that fund flows are less sensitive to performance during the most recent quarter than to performance during the remaining three quarters of the first year. This can be explained by information dissemination taking time and some investors reacting to fund performance with a certain lag. The impact of past performance on flows is mostly limited to the three most recent years of performance history, which accounts for about 90% of the total impact.

The well-documented convexity of the flow-performance relationship is robust to allowing for our more flexible dynamic lag structure and dependence of this relationship on size and age of the fund. This convexity seems to be mostly due to the difference in flows between the top performing half of the funds and bottom performing half of the funds. Within each of these two segments the flow-performance relationship appears close to linear, which suggests that funds with the average performance have more incentives to take excessive risk as a result of the convexity in the flow-performance relationship.

Finally, we find that performance on systematic risk factors has a small positive impact on flows in excess of the impact of the risk-adjusted returns. This suggests that some mutual fund investors are style timers choosing funds on the basis of their raw rather than risk-adjusted performance. However, this finding could be specific for our sample period (1991-1998), during most of which the systematic factors realized positive returns.

References

Baks, Klaas, Andrew Metrick, and Jessica Wachter, 2001, Should investors avoid all actively managed mutual funds? A study in Bayesian performance evaluation, *Journal of Finance* 56, 45-85.

Barber, Brad M., Terrance Odean, and Lu Zheng, 2001, Out of sight, out of mind. The effect of expenses on mutual fund flows, working paper, Graduate School of Management, UC Davis and School of Business Administration, University of Michigan.

Brown, Stephen J., and William N. Goetzmann, 1995, Performance persistence, *Journal of Finance* 50, 679-698.

Brown, Keith C., W. V. Harlow, and Laura T. Starks, 1996, Of tournaments and temptations: An analysis of managerial incentives in the mutual fund industry, *Journal of Finance* 51, 85-110.

Busse, Jeffrey A., 2001, Another look at mutual fund tournaments, *Journal of Financial and Quantitative Analysis* 36, 53–73.

Capon, Noel, Gavan J. Fitzsimons, and Russ Alan Prince, 1996, An individual level analysis of mutual fund investment decision, *Journal of Financial Services Research* 10, 59-82.

Carhart, Mark M., 1997, On persistence in mutual fund performance, *Journal of Finance* 52, 57-82.

Chevalier, Judith, and Glenn Ellison, 1997, Risk taking by mutual funds as a response to incentives, *Journal of Political Economy* 105, 1167-1200.

Chevalier, Judith, and Glenn Ellison, 1999, Are some mutual fund managers better than others? Cross-sectional patterns in behavior and performance", *Journal of Finance*, 54, 875-899.

Del Guercio, Diane, and Paula A. Tkac, 2000, The determinants of the flow of funds of managed portfolios: Mutual funds versus pension funds, working paper 2000-21, Federal Reserve Bank of Atlanta.

Geweke, John, 1978, Temporal aggregation in the multiple regression model, *Econometrica* 46, 643-661.

Goetzmann, William N. and Nadav Peles, 1997, Cognitive dissonance and mutual fund investors, *Journal of Financial Research* 20, 145-158.

Goriaev, Alexei P., Theo E. Nijman, and Bas J.M. Werker, 2001, Yet another look at mutual fund tournaments, working paper, Tilburg University.

Gruber, Martin J., 1996, Another puzzle: The growth in actively managed mutual funds, *Journal of Finance* 51, 783-810.

Hendricks, Darryl., Jay Patel and Richard Zeckhauser, 1993, "Hot hands in mutual funds: short run persistence of relative performance, 1974-1988", *Journal of Finance*, 48, 93-130.

Ippolito, Richard A., 1992, Consumer reaction to measures of poor quality: Evidence from the mutual fund industry, *Journal of Law and Economics* 35, 45-70.

Ivkovic, Zoran, 2000, Is blood thicker than water: Spillovers in mutual fund families: Evidence from the mutual fund industry, working paper, Yale School of Management.

Jain, Prem C. and Joanna S. Wu, 1999, Truth in mutual fund advertising: Evidence on future performance and fund flows, working paper, A.B. Freeman School of Business and W.E. Simon Graduate School of Business Administration.

Khorana, Ajay, 1996, Top management turnover. An empirical investigation of mutual fund managers, *Journal of Financial Economics* 40, 403-427.

Nanda, Vikram, Zhi Wang, and Lu Zheng, 2000, Family values and the star phenomenon, working paper, University of Michigan Business School.

Sirri, Erik R., and Peter Tuffano, 1998, Costly search and mutual fund flows, *Journal of Finance* 53, 1589-1622.

Wermers, Russ, 2000, Mutual fund performance: an empirical decomposition into stock picking talent, style transaction costs and expenses", *Journal of Finance* 55, 1655-1695.

Zeckhauser, Richard, Jayendu Patel, and Darryll Hendricks, 1991, Nonrational actors and financial market behavior, *Theory and Decision* 31, 257-287.

Table 1
Summary statistics of the US growth funds, 1991-1998

The table reports summary statistics of the US growth funds during the main sample period (1991-1998). Columns 2 and 3 report mean and standard deviation, while the last two columns present means of the fund characteristics in the respective top and bottom quintiles. Note that Jensen's alpha, absolute and relative flows are annualized.

Fund characteristic	Mean	Std. Dev.	Mean (bottom quintile)	Mean (top quintile)
Absolute flow, \$ mln	49.87	382.57	-214.95	460.74
Relative flow, %	5.36	40.59	-36.00	61.34
Total Net Assets, \$ mln	732.35	1228.44	18.25	2617.05
Age, years	16.27	10.37	5.98	31.29
Jensen's alpha, %	-0.13	3.24	-4.50	4.42
Nonsystematic risk, %	17.53	6.46	10.56	27.53

Table 2
Flow-performance relationship: a typical model in the literature

The table reports coefficient estimates based on the typical model used in the literature (9) for the period 1991-1998. The dependent variable is fund net relative flow. The independent variables include a constant, log of fund size, log of fund age, and five-year Jensen's alpha. Note that relative flows and Jensen's alpha are annualized.

	Coef	S.e.
$Const$	15.52	1.259
$\log TNA_{i,t-1}$	-0.64	0.145
$\log age_{i,t-1}$	-4.20	0.410
$\alpha_{i,t}$	3.79	0.076

Table 3
Lag structure of the flow-performance relationship

Columns 3 and 4 of the table report coefficient estimates based on the basic specification (4) for the period 1991-1998. The last two columns of the table report coefficient estimates based on the specification (11) for the period 1976-1998, including the period 1976-1990 with quarterly data on flows. The dependent variable is fund net absolute flow. The independent variables include the performance-unrelated term and flow-performance sensitivity times weighted sum of past 60 monthly risk-adjusted returns. Both the performance-unrelated term and flow-performance sensitivity are modelled as a quadratic function of logs of fund size and age. The performance coefficients are restricted to lie on a polynomial of the fifth order (see (7)). Note that flows and Jensen's alpha are annualized.

		Coef	S.e.	Coef	S.e.
Performance-	$Const$	202.42	14.691	198.49	12.741
unrelated	$\log TNA$	61.96	4.354	57.23	3.959
flows	$\log^2 TNA$	4.93	0.434	4.23	0.377
(function G)	$\log age$	-77.63	9.010	-79.58	6.604
	$\log^2 age$	7.73	1.481	7.69	1.063
	$\log TNA * \log age$	-11.07	1.096	-11.13	0.875
Flow-	$Const$	66.15	5.149	39.5	3.929
performance	$\log TNA$	25.53	1.041	12.56	1.109
sensitivity	$\log^2 TNA$	2.53	0.085	1.19	0.097
(function H)	$\log age$	-13.89	3.087	-11.8	1.663
	$\log^2 age$	1.00	0.480	1.41	0.226
	$\log TNA * \log age$	-2.22	0.258	-1.12	0.183
Lag structure	θ_0	-0.02	0.001	-0.02	0.001
of past	θ_1	1.19	0.049	1.17	0.084
performance	θ_2	-4.40	0.406	-4.25	0.688
	θ_3	4.62	0.665	4.42	1.134
	θ_4	-1.58	0.295	-1.51	0.506
	θ_5	0.15	0.032	0.14	0.055

Table 4
Tests of the hypotheses about the lag structure of the flow-performance relationship

Panels A and B of the table describes tests based on the basic specification (4) for the periods 1991-1998 and 1976-1998, respectively. The lower diagonal part of the table presents p-values of the tests of the hypothesis that the impact of past performance i months ago equals that of j months ago, $H_0 : w_i = w_j$. The upper diagonal part of the table reports p-values of the tests of the hypothesis that the impact of past performance i quarters ago equals that of j quarters ago, $H_0 : w_{3i-2} + w_{3i-1} + w_{3i} = w_{3j-2} + w_{3j-1} + w_{3j}$.

Panel A. Sample period 1991-1998

$i \backslash j$	1	2	3	4	5	6	7	8	9	10
1	-	0.1144	0.0058	0.0407	0.6130	0.2534	0.0075	0.0001	0.0000	0.0000
2	0.7594	-	0.0019	0.5891	0.0554	0.0001	0.0000	0.0000	0.0000	0.0000
3	0.6053	0.3921	-	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
4	0.5908	0.4109	0.8621	-	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
5	0.2478	0.1773	0.5767	0.0237	-	0.0000	0.0000	0.0000	0.0000	0.0000
6	0.0933	0.0684	0.2952	0.0023	0.0000	-	0.0000	0.0000	0.0000	0.0000
7	0.0515	0.0360	0.1928	0.0008	0.0001	0.0029	-	0.0000	0.0000	0.0000
8	0.0465	0.0297	0.1743	0.0011	0.0014	0.0692	0.6831	-	0.0000	0.0000
9	0.0613	0.0358	0.2083	0.0041	0.0238	0.4620	0.4817	0.0446	-	0.0000
10	0.0993	0.0549	0.2967	0.0211	0.1832	0.8010	0.0851	0.0020	0.0000	-

Panel B. Sample period 1976-1998

$i \backslash j$	1	2	3	4	5	6	7	8	9	10
1	-	0.4337	0.115	0.3386	0.8073	0.1388	0.0091	0.0003	0.0000	0.0000
2	0.5319	-	0.0804	0.9441	0.1407	0.0053	0.0001	0.0000	0.0000	0.0000
3	0.8241	0.6345	-	0.0106	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
4	0.7603	0.6036	0.9747	-	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
5	0.9561	0.4003	0.6952	0.1710	-	0.0000	0.0000	0.0000	0.0000	0.0000
6	0.7221	0.2653	0.5026	0.0689	0.0102	-	0.0000	0.0000	0.0000	0.0000
7	0.6208	0.2084	0.4179	0.0462	0.0205	0.1085	-	0.0000	0.0000	0.0000
8	0.6200	0.2000	0.4067	0.0563	0.0768	0.3881	0.9953	-	0.0000	0.0000
9	0.6883	0.2237	0.4511	0.1014	0.2472	0.8482	0.4972	0.1449	-	0.0000
10	0.8047	0.2738	0.5440	0.2081	0.5727	0.6794	0.1966	0.0358	0.0041	-

Table 5

Quintile-specific lag structure of the flow-performance relationship

The table reports coefficient estimates based on the model (12) for the period 1991-1998. The dependent variable is fund net absolute flow. The independent variables include the performance-unrelated term and flow-performance sensitivity times weighted sum of past 60 monthly risk-adjusted returns. Both the performance-unrelated term and flow-performance sensitivity are modelled as a quadratic function of logs of fund size and age. The quintile-specific performance coefficients are restricted to lie on a polynomial of the fifth order (see (13)). The quintiles are defined on the basis of the five-year Jensen's alpha. Note that flows and Jensen's alpha are annualized.

		Coef	S.e.
Performance-	$Const$	165.42	20.748
unrelated	$\log TNA$	48.48	8.331
flows	$\log^2 TNA$	3.69	0.866
(function G)	$\log age$	-67.59	7.860
	$\log^2 age$	6.91	1.326
	$\log TNA * \log age$	-9.45	1.065
Flow-	$Const$	62.94	5.369
performance	$\log TNA$	24.4	1.123
sensitivity	$\log^2 TNA$	2.44	0.098
(function H)	$\log age$	-13.45	3.321
	$\log^2 age$	1.01	0.543
	$\log TNA * \log age$	-2.16	0.276
Lag structure	θ_0	-0.01	0.002
in the bottom	θ_1	0.94	0.168
quintile	θ_2	-3.55	0.954
	θ_3	3.88	1.361
	θ_4	-1.39	0.568
	θ_5	0.13	0.06

Lag structure in quintile 2	θ_0	-0.01	0.003
	θ_1	0.38	0.192
	θ_2	0.05	1.217
	θ_3	-1.37	1.799
	θ_4	0.81	0.758
	θ_5	-0.1	0.08
Lag structure in quintile 3	θ_0	-0.02	0.003
	θ_1	1.34	0.229
	θ_2	-4.82	1.398
	θ_3	4.71	1.988
	θ_4	-1.48	0.818
	θ_5	0.13	0.086
Lag structure in quintile 4	θ_0	-0.02	0.002
	θ_1	1.50	0.175
	θ_2	-5.99	1.093
	θ_3	6.62	1.623
	θ_4	-2.33	0.687
	θ_5	0.22	0.073
Lag structure in the top quintile	θ_0	-0.02	0.002
	θ_1	1.67	0.144
	θ_2	-6.74	0.99
	θ_3	7.76	1.534
	θ_4	-2.87	0.666
	θ_5	0.29	0.072

Table 6
Tests of the hypotheses about the quintile-specific lag structure of the flow-performance relationship

The table describes tests based on the specification (12) for the period 1991-1998. The lower diagonal part of the table presents p-values of the tests of the hypothesis that the average impact of past performance on flows of funds in quintile p equals that in quintile r, $H_0 : \sum_j w_j(p) = \sum_j w_j(r)$, $\forall p, r$.

$p \backslash r$	1	2	3	4	5
1	-				
2	0.2795	-			
3	0.0327	0.0005	-		
4	0.0079	0.0000	0.7784	-	
5	0.0000	0.0000	0.0877	0.1688	-

Table 7

Lag structure of the flow-performance relationship: raw vs. risk-adjusted performance

The table reports coefficient estimates based on the model (14) for the period 1991-1998. The dependent variable is fund net absolute flow. The independent variables include the performance-unrelated term and flow-performance sensitivity times weighted sum of past 60 monthly risk-adjusted returns and past 60 raw returns. Both the performance-unrelated term and flow-performance sensitivity are modelled as a quadratic function of logs of fund size and age. The coefficients on raw and risk-adjusted returns are restricted to lie on a polynomial of the fifth order (see (7)). Note that flows and Jensen's alpha are annualized.

		Coef	S.e.
Performance-unrelated flows (function G)	$Const$	11.9	37.865
	$\log TNA$	-6.93	13.692
	$\log^2 TNA$	-1.64	1.324
	$\log age$	-30.19	10.757
	$\log^2 age$	3.7	1.319
	$\log TNA * \log age$	-4.28	1.437
Flow-performance sensitivity (function H)	$Const$	68.25	5.145
	$\log TNA$	27.11	1.027
	$\log^2 TNA$	2.69	0.090
	$\log age$	-12.82	3.125
	$\log^2 age$	0.69	0.499
	$\log TNA * \log age$	-2.29	0.246
Lag structure, risk-adjusted returns	θ_0	-0.02	0.001
	θ_1	1.18	0.102
	θ_2	-4.94	0.716
	θ_3	5.72	1.090
	θ_4	-2.10	0.464
	θ_5	0.21	0.049
Lag structure, raw returns	θ_0	0.00	0.001
	θ_1	0.08	0.103
	θ_2	0.09	0.702
	θ_3	-0.45	1.021
	θ_4	0.25	0.419
	θ_5	-0.03	0.044

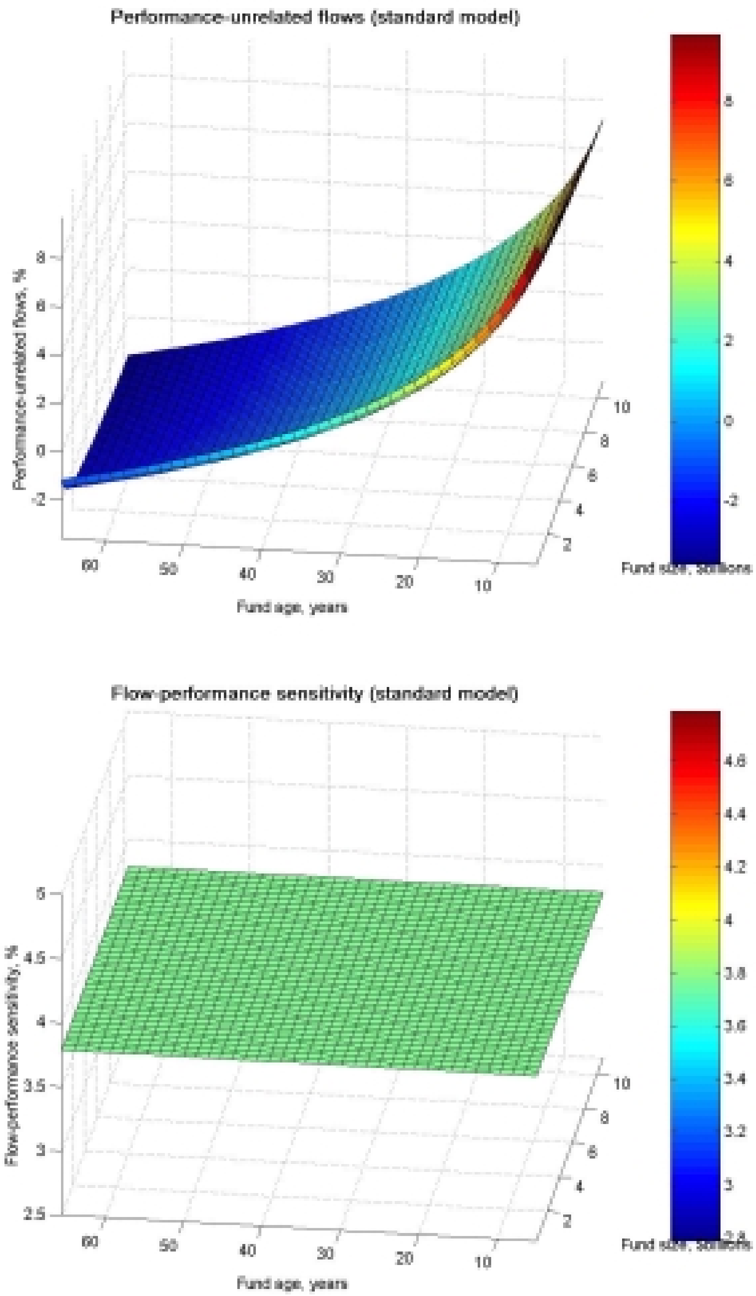

Figure 1. Expected fund flows as a function of size and age (standard model)

Panels A and B show the performance-unrelated flows (flows of a fund with zero Jensen's alpha) and flow-performance sensitivity (change in fund flows due to 1% increase in Jensen's alpha), predicted by the standard model in the literature (9). The performance-unrelated flows are modelled as linear in logs of size and age. The flow-performance sensitivity is assumed to be constant.

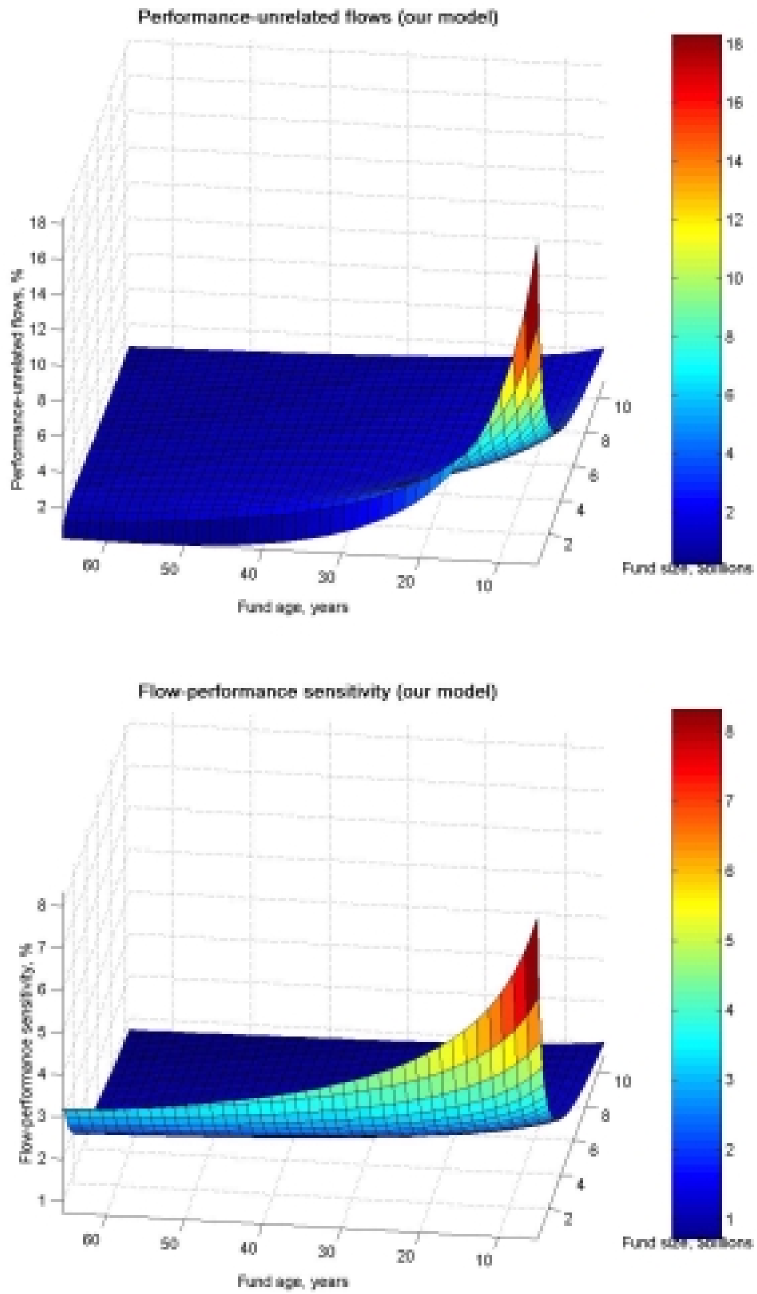

Figure 2. Expected fund flows as a function of size and age (our model)

Panels A and B show the performance-unrelated flows (flows of a fund with zero Jensen's alpha) and flow-performance sensitivity (change in fund flows due to 1% increase in Jensen's alpha), based on the basic specification (4) for the period 1991-1998. Both the performance-unrelated flows and flow-performance sensitivity are modelled as a quadratic function in logs of fund size and age.

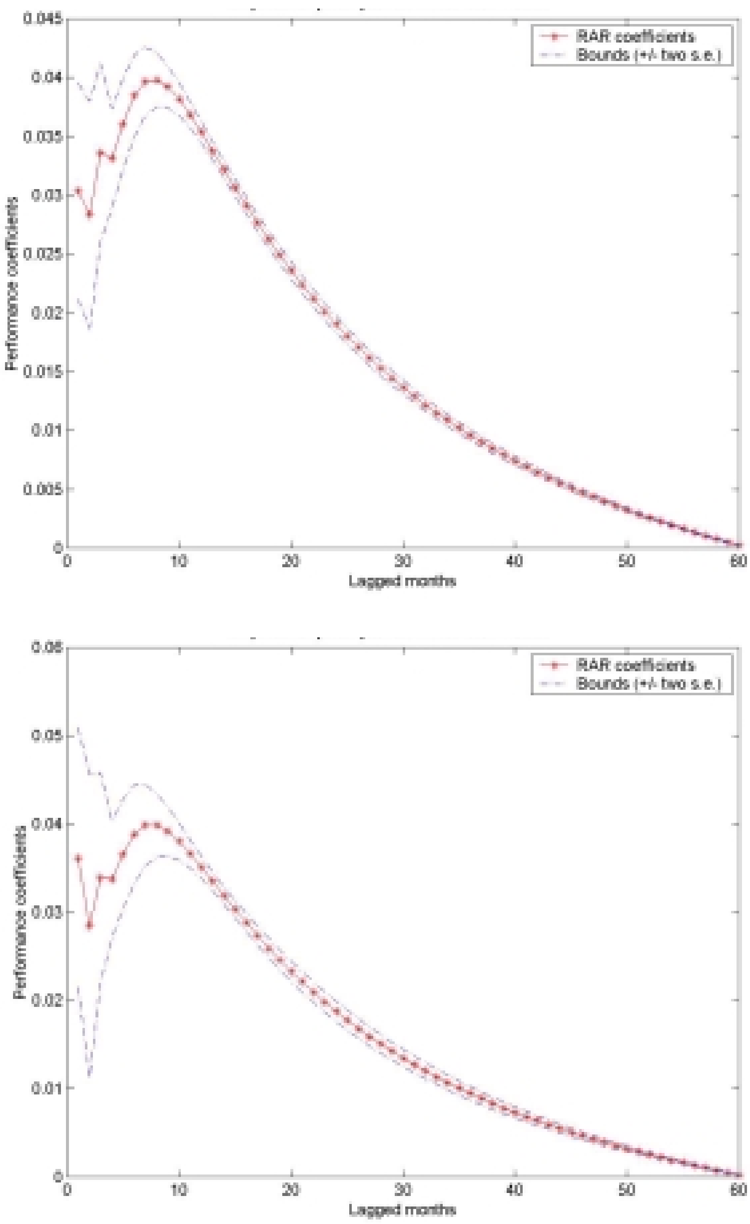

Figure 3. Impact of past performance on flows

The graph shows the lag structure of the impact of past 60 monthly risk-adjusted returns on current flows. The performance coefficients are restricted to lie on a polynomial of the fifth order (see (7)). Panels A and B are based on the basic specification (4) for the period 1991-1998 and modified specification (11) for the period 1976-1998 (including the period 1976-1990 with quarterly data on flows), respectively.

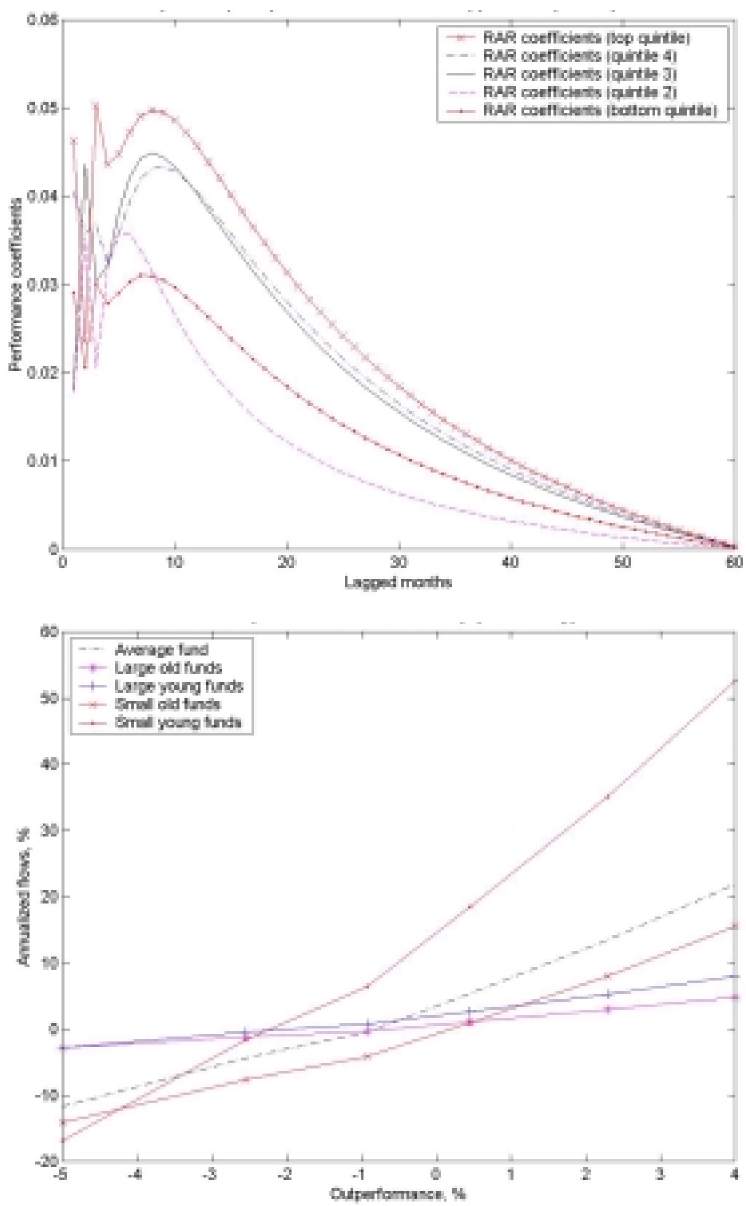

Figure 4. Quintile-specific impact of past performance on flows

Panel A shows the lag structure of the impact of past 60 monthly risk-adjusted returns on current flows, based on the model (12) for the period 1991-1998. The quintile-specific performance coefficients are restricted to lie on a polynomial of the fifth order (see (13)). The performance quintiles are defined on the basis of the five-year Jensen's alpha. Panel B depicts expected flows for funds with five different combinations of size and age. An average fund has an age of 16 years and \$732 mln in assets. Small and large funds have a size of \$250 mln and \$8 bln, while young and old funds have an age of 5 and 50 years, respectively.

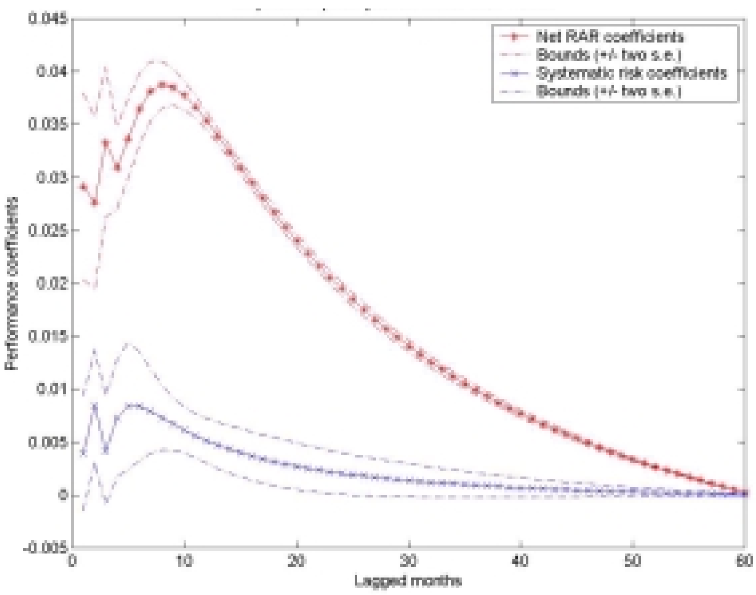

Figure 5. Impact of raw and risk-adjusted performance on flows

The graph shows the lag structure of the net impact of past 60 monthly risk-adjusted and raw returns on current flows, based on the model (14) for the period 1991-1998. The coefficients on raw and risk-adjusted returns are restricted to lie on a polynomial of the fifth order (see (7)).